

# Liquid Argon Field Calibration System (LArFCS) DAQ

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# Information for the FADC selection

- 192 detection wires from TPC
  - U, V planes: 48 wires each.
  - Y plane: 96 wires.
- FE goes with MicroBooNE design
  - 2 Vpp output (from intermediate amplifier).
  - Differential output.
- Minimum sampling rate depends on the shaper peaking time
  - 0.5, 1.0, 2.0, 3.0  $\mu$ s available shaping times.
  - 2+ MS/sec/ch for all channels run simultaneously.
- 12-bit FADC resolution.

# DAQ system candidates

- MicroBooNE designed DAQ system
  - Complicated to use NEVIS FPGA readout.
- Commercial DAQ system
  - Huchen can help us to design a receiver board (from intermediate amplifier to FADC).
  - Lindsey has DAQ program for 1-ton WbLS system that we can learn from.
- Commercial DAQ system investigated
  - National Instrument's PXI system. (**rule out**)
  - CAEN's VME system.

# Components needed for Large LAr DAQ system

The followings are components that we will need

- VME Power Crate
- VME Modules
  - VME controller
  - Digitizers (FADCs)
  - PCI card with optical connecting fibers
- Desktop computer and monitors
- Multiple LabVIEW licenses

# VME Power Crates

## Powered Crates

	VME8001	1U 2 Slot VME64 Mini Crate
DIS	VME8002	5U 9 Slot VME64 Mini Crate
	VME8004B	2U 4 Slot VME64 Mini Crate
NEW	VME8004X	2U 4 Slot VME64X Mini Crate
DIS	VME8008	4U 8 Slot VME64 Mini Crate
NEW	VME8008B	4U 8 Slot VME64 Mini Crate
NEW	VME8008X	4U 8 Slot VME64X Mini Crate
	VME8010	7U 21 Slot VME64 Low Cost Crate
	VME8011	7U 21 Slot VME64 Low Cost Crate
	VME8100	8U 21 Slot VME64/64X Enhanced Crate Series
	VME8200	9U 21Slot VME64X Enhanced Crate series

- 21 slots
- Used in Lindsey's DAQ system



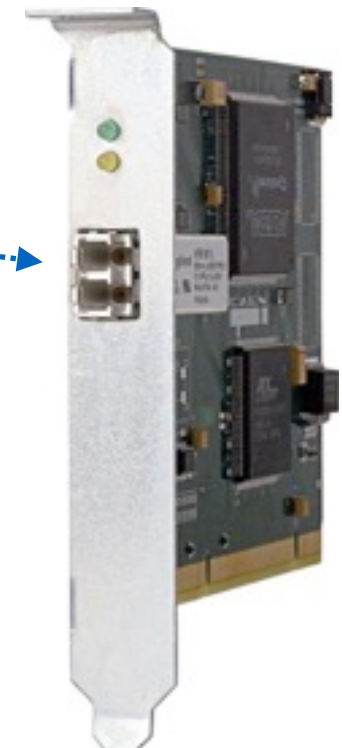
# VME Controllers and PCI cards

## Controller (VME)

V1718	VME-USB2.0 Bridge
V2718	VME-PCI Optical Link Bridge
VX1718	VME-USB2.0 Bridge
VX2718	VME-PCI Optical Link Bridge

## Optical Controllers

A2818	PCI CONET Controller
A3818	PCI Express CONET2 Controller



## Digitizers

	V1720	8 Channel 12bit 250 MS/s Digitizer
	V1721	8 Channel 8 bit 500 MS/s Digitizer
	V1724	8 Channel 14 bit 100 MS/s Digitizer
NEW	V1725	16/8 Channel 14-bit 250 MS/s Digitizer
DIS	V1729	4 Channel 12 bit 2 GS/s (300 MHz bandwidth) Switched-Capacitor Digitizer
	V1729A	4 Channel 14 bit 2 GS/s (300 MHz bandwidth) Switched-Capacitor Digitizer
	V1730	16/8 Channel 14-bit 500 MS/s Digitizer
	V1731	4/8 Ch. 8 bit 1000/500 MS/s Digitizer
	V1740	64 Channel 12 bit 62.5 MS/s Digitizer
NEW	V1740D	64 Channel 12 bit 62.5 MS/s Digitizer supporting DPP-QDC firmware
	V1742	32+2 Channel 12bit 5 GS/s Switched Capacitor Digitizer
NEW	V1743	16 Channel 12bit 3.2 GS/s Switched Capacitor Digitizer
	V1751	4-8 Channel 10 bit 2/1 GS/s Digitizer
NEW	V1761	2 Channel 10 bit 4GS/s Digitizer
DIS	V729	4 Channel 12 bit 40 MS/s Digitizer
	VX1720	8 Channel 12bit 250 MS/s Digitizer
	VX1721	8 Channel 8 bit 500 MS/s Digitizer
	VX1724	8 Channel 14 bit 100 MS/s Digitizer
NEW	VX1725	16/8 Channel 14-bit 250 MS/s Digitizer
NEW	VX1730	16/8 Channel 14-bit 500 MS/s Digitizer
	VX1731	4/8 Ch. 8 bit 1000/500 MS/s Digitizer
	VX1740	64 Channel 12bit 62.5 MS/s Digitizer
NEW	VX1740D	64 Channel 12bit 62.5 MS/s Digitizer supporting DPP-QDC firmware
	VX1742	32+2 Channel 12bit 5 GS/s Digitizer
NEW	VX1743	16 Channel 12bit 3.2 GS/s Switched Capacitor Digitizer
	VX1751	4-8 Channel 10 bit 2/1 GS/s Digitizer
NEW	VX1761	2 Channel 10 bit 4GS/s Digitizer

## CAEN VME digitizers

### Not many choices?!

- Only 16+ channels and 12+ bits FADC considered
  - Large number of wire readout.
  - 12-bit resolution is required
  - Differential input type (use differential to single-end converter?)

192-channel TPC	
channels	modules
8-ch	24
16-ch	12
32-ch	6
64-ch	3

We don't have to read out all wires at the same time!



## Digitizers

	V1720	8 Channel 12bit 250 MS/s Digitizer	\$ 6,000 - \$ 7,000	✗
	V1721	8 Channel 8 bit 500 MS/s Digitizer		
	V1724	8 Channel 14 bit 100 MS/s Digitizer	\$ 6,000 - \$ 7,000	✗
NEW	V1725	16/8 Channel 14-bit 250 MS/s Digitizer	\$ 9,000 - \$ 10,000	✗
DIS	V1729	4 Channel 12 bit 2 GS/s (300 MHz bandwidth) Switched-Capacitor Digitizer		
	V1729A	4 Channel 14 bit 2 GS/s (300 MHz bandwidth) Switched-Capacitor Digitizer		
	V1730	16/8 Channel 14-bit 500 MS/s Digitizer	\$ 15,000 - \$ 16,000	✗
	V1731	4/8 Ch. 8 bit 1000/500 MS/s Digitizer		
	V1740	64 Channel 12 bit 62.5 MS/s Digitizer	\$ 10,000 - \$ 11,000	✓
NEW	V1740D	64 Channel 12 bit 62.5 MS/s Digitizer supporting DPP-QDC firmware		
	V1742	32+2 Channel 12bit 5 GS/s Switched Capacitor Digitizer		
NEW	V1743	16 Channel 12bit 3.2 GS/s Switched Capacitor Digitizer		
	V1751	4-8 Channel 10 bit 2/1 GS/s Digitizer		
NEW	V1761	2 Channel 10 bit 4GS/s Digitizer		
DIS	V729	4 Channel 12 bit 40 MS/s Digitizer		



# VME system (CAEN) cost estimation

- Quotations from CAEN and delivery takes ~ 2 - 6 weeks.

Modules	Cost
VME Crate WV8010	\$3631.22
Controller V2718	\$2762.66
PCI card A2818 / A3818	\$1263.36 / \$2436.48
Sub total	<b>~ \$ 8K - \$ 9K</b>
Digitizer V1740	\$10,000 - \$ 11,000
VME System Cost Estimation	
192-ch (3 modules)	~ \$ 38K - \$ 42K
<b>96-ch (2 modules)</b>	<b>~ \$ 28K - \$ 31K</b>
64-ch (1 modules)	~ \$ 18K - \$ 20K



# Summary

- Our DAQ system will go with CAEN VME system.
- The total cost of the DAQ system is about \$35K to \$ 40K.

Estimated Total Cost of the DAQ system	
VME System	~ \$ 28K - \$ 31K
DAQ Computer (monitors)	~ \$1.5 K - \$ 2 K
LabVIEW licenses	~ \$ 5 K
<b>Total Cost</b>	<b>~ \$ 35K - \$ 40K</b>

# Back up

# National Instrument (NI) PXI System

	PXIe 6365	PXIe 6368
Channels	144	16
Voltage input range	$\pm 0.1\text{ V}$ , $\pm 0.2\text{ V}$ , $\pm 0.5\text{ V}$ , $\pm 1\text{ V}$ , $\pm 2\text{ V}$ , $\pm 5\text{ V}$ , $\pm 10\text{ V}$	$\pm 1\text{ V}$ , $\pm 2\text{ V}$ , $\pm 5\text{ V}$ , $\pm 10\text{ V}$
Resolution	16 bits	16 bits
Sampling rate	1 MS/sec/ch max 	2 MS/sec/ch
Sampling type	multiplexed	simultaneous
Total cost (128-ch Single-end input)	<b>~ \$ 15 K</b>	<b>~ \$ 105 K</b> 

- PXIe-6368 is more expensive compared with VME system.
- PXIe-6365's sampling rate is too low for our application
  - 7 KS/sec for 144 channels run simultaneously

**Rule out NI PXI System!**

## V1740

### 64 Channel 12 bit 62.5 MS/s Digitizer



- 12 bit 62.5 MS/s ADC
- 64 channels
- Two ERNI SMC Dual Row 68pin connectors (32 + 32 channels)
- 2 Vpp single ended input range (10 Vpp also available)
- 16-bit programmable DC offset adjustment:  $\pm 1$  V ( $\pm 5$  V)
- Trigger Time stamps
- Memory buffer: 192 kS/ch or 1.5 MS/ch, up to 1024 events
- FPGA for real-time data processing
- Programmable event size and pre-post trigger adjustment

[More](#)

# V1725

## 16/8 Channel 14-bit 250 MS/s Digitizer



+ Image

### Highlights

- 14-bit @ 250 MS/s
- Analog inputs on MCX coaxial connectors
- 16/8 channels, 1-unit wide 6U VME64 module
- 0.5 and 2 Vpp selectable input dynamic range with programmable DC offset adjustment
- Algorithms for Digital Pulse Processing
  - Pulse Height Analysis (DPP-PHA)
  - Pulse Shape Discrimination (DPP-PSD)
  - Zero Length Encoding (DPP-ZLEplus) - **COMING SOON**
- VME64 (VME64X compliant) and Optical Link communication interfaces
- Multi-board synchronization features
- 16 programmable LVDS I/Os
- Daisy chain capability
- Demo software tools, DPP Control Software, C and LabVIEW libraries

# Estimation of the data rate

## Assumption

- The TPC has 192 wires (read out 96 wires)
- We use 12 bits FADC to record the waveforms
- ADC sampling rate is adjusted to 2 MS/sec
- The electron drift velocity is 1.6 mm/ $\mu$ s, and the drift distance is 100 mm, assign 70  $\mu$ s for each event measurement (1 time frame).

## Estimation

- For each data taking time frame the data size is:

$$\frac{1.5 \text{ bytes}}{S} \cdot \frac{2 \text{ MS}}{\text{sec}} \cdot 70 \times 10^{-6} \text{ sec} \cdot 96 = 2.016 \times 10^{-2} \text{ Mb}$$

Each sample      Sampling rate      Sampling time      Channel readout

- 100 Hz event rate, the data rate is:  $\sim 2 \text{ Mb/sec}$
- If take 3 time frames for each event like MicroBooNE does:  $\sim 6 \text{ Mb/sec}$ .



# VME system (CAEN) cost estimation

- Quotations from CAEN and delivery takes ~ 2 - 6 weeks.

Modules	Properties	Cost
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Controller V2718		\$2762.66
PCI card A2818 / A3818		\$1263.36 / \$2436.48
Sub total		<b>~ \$ 8K - \$ 9K</b>
Digitizer V1740	12-bit, 64-ch, 2 V p-p, 62.5 MS/sec	\$10,000 - \$ 11,000
Digitizer V1725	14-bit, 16-ch, 2 V p-p, 250 MS/sec	\$9,000 - \$10,000

Cost Estimation	V1740	V1725
192-ch	<b>~ \$ 38K - \$ 42K</b>	<b>~ \$ 116 K - \$ 129 K</b>
<b>96-ch</b>	<b>~ \$ 28K - \$ 31K</b>	<b>~ \$ 62 K - \$ 69 K</b>
64-ch	<b>~ \$ 18K - \$ 20K</b>	<b>~ \$ 44 K - \$ 49 K</b>
32-ch	<b>~ \$ 18K - \$ 20K</b>	<b>~ \$ 26 K - \$ 29K</b>